INSTRUCTION MANUAL

REGATRON

POWER SUPPLY

MODEL 228A

SERIAL No. _____

ELECTRONIC MEASUREMENTS
COMPANY, INCORPORATED
EATONTOWN · NEW JERSEY

TELEPHONE: (201) LIberty 2-0300 TWX: (201) 542-2273 CABLE: ELMEASCO

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2. On receipt of shipping instructions, forward the appartus to us, prepaid, and we will make repairs and adjustments immediately at the factory.

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REGATRON®
PROGRAMMABLE
POWER SUPPLY

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SERIAL No. _____

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COMPANY, INCORPORATED
EATONTOWN · NEW JERSEY

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Eatontown, New Jersey

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E/M* REGATRON POWER SUPPLY

TABLE OF SPECIFICATIONS

MODEL	DC OUTPUT		INPUT POWER REQUIRED IN WATTS	DIMENSIONS IN INCHES			APPROX. WEIGHT IN LBS.
	VOLTS	AMPERES		PANEL HEIGHT	PANEL WIDTH	DEPTH BEHIND PANEL	
225A	0-75	0-2	680	8-3/4	19	14-9/16	46
226A	0-100	0-2	740	8-3/4	19	14-9/16	46
228A	0-150	0-1	510	8-3/4	19	14-9/16	45
230A	0-200	0-1	600	8-3/4	19	14-9/16	46

REGULATION
LINE: 0.1% or 0.05 volts, whichever is greater, for line change from 105 to 125 volts ac, 50-60 cps.
LOAD: 0.1% or 0.05 volts, whichever is greater, from no load to full load.

REGULATION WITH CHOPPER STABILIZATION
LINE OR LOAD: 0.01% or 3 millivolts, whichever is greater.

STABILITY: Within 0.1% or 50 millivolts, whichever is greater, for 8-hours after 30-minute warmup under fixed line, load, and temperature conditions, and using precision high-stability external programming resistor.

STABILITY WITH CHOPPER STABILIZATION: 0.05% + 2 millivolts, same as conditions above.

RIPPLE: 1 millivolts RMS maximum with positive or negative output grounded.

OUTPUT IMPEDANCE: Less than .01 ohm at low audio frequencies; 0.1 ohm to 10 KC; 1 ohm to 40 KC.

TRANSIENT RESPONSE: For step change from no load to full or full to no load, output recovers to within dc regulation limits of initial value within 1 millisecond.

PROGRAMMING CONSTANT: 1,000 ohms-per-volt of output.

REMOTE SENSING: Panel terminals permit sensing of positive and negative output leads.

AMBIENT TEMPERATURE RANGE: -20°C to +45°C.

OUTPUT GROUND: Positive, negative or floating output.

CIRCUIT PROTECTION: Input ac line fused, dc output fused.

TERMINATIONS: Front: 5-way insulated binding posts. Rear: barrier-type terminal strips. Line cord is 3-conductor type.

CONTROLS: Main voltage control and vernier are wirewound. Panel calibration is approximate.

MOUNTING: Unit fits 19" standard racks and is equipped with rubber feet for table mounting. Top and bottom are protected by perforated metal covers.

FINISH: Smooth gray semi-gloss enamel Class 2 per MIL-E-15090.

*Registered U.S. Patent Office. Patents issued and pending.

Addendum #116

ELECTRONIC MEASUREMENTS COMPANY INC.

EATONTOWN, NEW JERSEY

INSTRUCTION MANUAL CHANGE

MODELS 225A, 226A, 228A, and 230A

10-6-61 Page 4, paragraph 2-15, step a. and b. should read:

a. Remove the link across terminals 1 and 2 of TB1.
b. Connect the external reference across terminals 2 and 3 with the positive at terminal 3.

Parts list corrections:

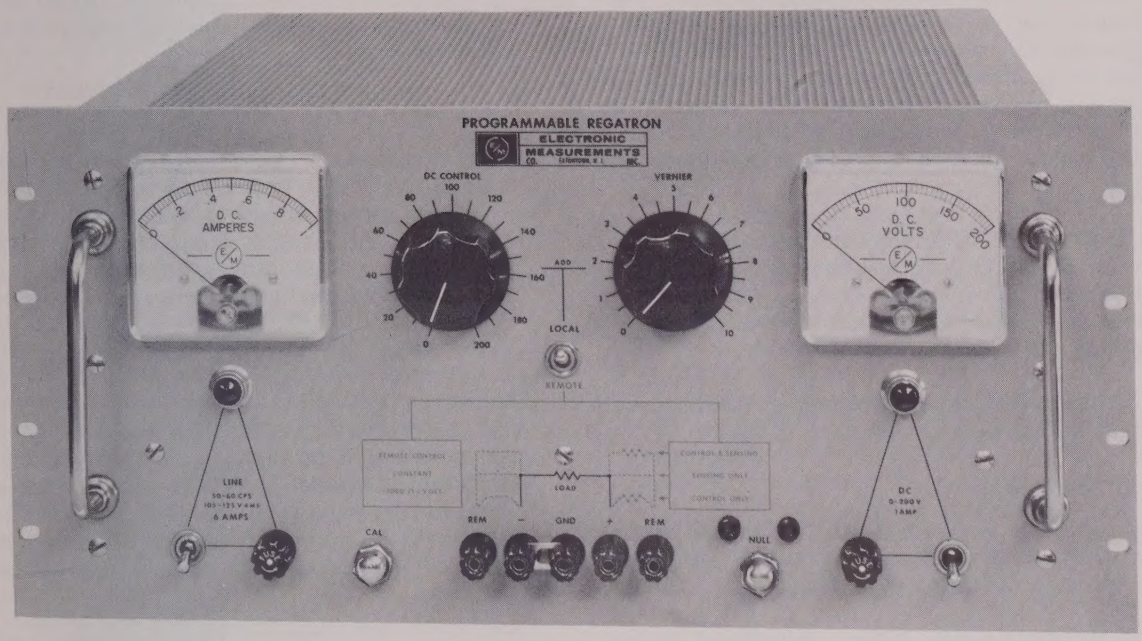
J3 Change Manufacturer to Eby.

R66,67 Delete (Model 228A/AK)

XV12-XV23 Delete XV23 and add XV19. Change manufacturer to Eby.

XV20,21 Change manufacturer to Eby.

XV22,23 Change manufacturer to Eby.



SECTION 1
DESCRIPTION

1-1. This Regatron Programmable Power Supply is a wide-range source of voltage-regulated dc power designed for general laboratory use, for incorporation into systems, or production test applications. It is especially suitable for transistor applications requiring stable low voltages. Output is continuously adjustable from zero to maximum voltage output. A vernier permits high resolution of output down to a fraction of a volt. Further detailed performance data is presented in the Specifications Table.

1-2. PROGRAMMING. The output voltage of this power supply can be controlled remotely, or programmed, with a resistor connected to the REM and + terminals. Output voltage then depends directly on the value of the programming resistor at a constant ratio of 1 volt per 1,000 ohms. This ratio remains constant over the entire output voltage range, even at a fraction of a volt. See paragraph 2-9 for instructions on programmed operation.

1-3. CONSTANT-CURRENT OUTPUT. This power supply can be converted from constant-voltage to constant-current output by means of simple external connections. See paragraph 2-17.

1-4. CHOPPER STABILIZATION. This manual covers both the standard and the chopper stabilized versions of this power supply.

SECTION 2
OPERATION

2-1. INSPECTION. Before placing the power supply in operation inspect the interior and check that all tubes are seated securely in their sockets. The top dust cover slides off towards the rear when the holding screws have been removed. Damage incurred in shipment should be handled in accordance with the instructions on the warranty page of this manual.

2-2. INSTALLATION. This unit operates on 105 to 125 volts, 50-60 cps, single-phase ac power. It may be rack-mounted or used on a table. Top and bottom covers can be removed for increased air circulation under high ambient temperatures.

2-3. FUSES. This unit contains the following fuses mounted on the front panel:

F1 in the ac line input

F2 in the + dc output to protect against short circuit or overloads. Replacement fuses must be of the values indicated on the panel.

2-4. PRELIMINARY. Before connecting ac line cord check that:

a. LINE switch is off.

b. DC switch is off.

c. DC CONTROL and VERNIER are at minimum, fully counter-clockwise.

d. REM-LOC switch is at appropriate position: LOC for panel control, REM for remotely programmed operation.

e. Swinging link is at desired grounding position, or disconnected for floating output.

2-5. LINE AND LOAD CONNECTIONS. Connect line cord to ac power outlet. Connect load to + and - output posts. Load wires should be heavy enough to prevent substantial IR drops between output posts and load in order to maintain the specified regulation of the power supply in actual service. The remote sensing connection described in paragraph 2-7 permits compensation for IR drops in load wires.

2-6. LOCAL OPERATION.

a. Throw LINE switch on. Green indicator should light.

b. Adjust DC CONTROL to desired voltage. Use the VERNIER for higher resolution to the desired voltage. Note that the DC CONTROL and VERNIER settings are additive.

c. After one minute, throw DC switch on. Red indicator should light. Desired voltage is now applied to load.

NOTE

Always allow a one-minute warmup period from a cold start before throwing DC switch on. In the off position this switch shorts the + to the - output post, thus effectively preventing application of any excess voltage to the load during warmup. Subsequently the DC switch can be thrown on or off with no danger of exceeding the desired output voltage.

2-7. REMOTE SENSING. For remote sensing for compensation of IR drops in the output leads, throw the REM-LOC switch to REM and connect the load as shown in figure 2-1. The sense leads should be connected to the terminals on the load in order to realize the rated regulation of the power supply at the load.

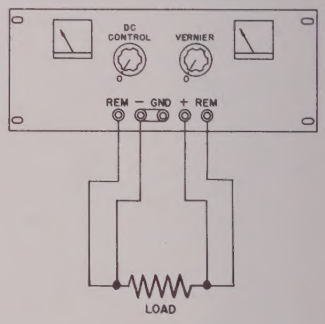


Figure 2-1.

Remote sensing connections, local operation

2-8. USE OF REAR TERMINATIONS. On units equipped with rear-mounted terminations only, the preceding operation instructions apply without change. On units equipped with both front and rear terminations, the following additional procedure applies to local operation from the rear terminals:

a. Throw REM-LOC switch to REM.

b. On rear terminal board, connect REM posts to adjacent output posts.

In remotely programmed use, either set of terminations can be employed in the normal manner as described in paragraphs 2-9 and 2-10. Control will then be derived from the set of terminals in use.

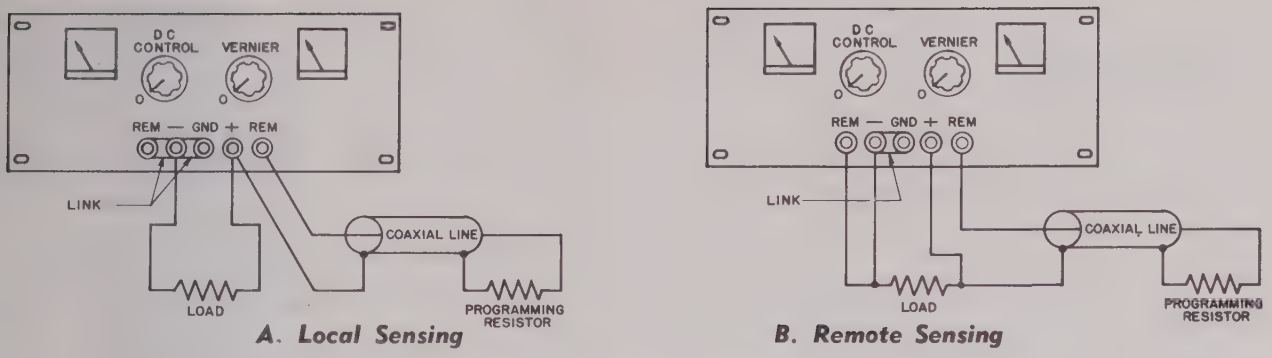


Figure 2-2. Programmed operation.

2-9. PROGRAMMED OPERATION. As stated in paragraph 1-2, the output of this power supply can be controlled from a remote point, or programmed, with a resistor, For programmed operation, proceed as follows:

a. Throw DC and LINE switches off.

b. Throw REM-LOC switch to REM.

c. Connect the load and programming resistor as shown in figure 2-2A. Output voltage depends on programming resistance in the ratio 1 : 1,000. For example, to obtain 50 volts, use a 50,000 ohms resistor.

d. Throw LINE switch on.

e. Set DC CONTROL and VERNIER to zero.

f. Throw DC switch on. Programmed voltage is now applied to load.

2-10. REMOTE SENSING, PROGRAMMED USE. Where load and control resistor are far from the unit but near each other the method of figure 2-2B will eliminate the effect of voltage drops in the output leads, yielding remote sensing for regulation at the load.

2-11. PROGRAMMING CONSIDERATIONS. The following considerations should be carefully noted before programming this power supply:

a. An open in a remote control circuit is effectively a high programming resistance and, accordingly, will cause an uncontrolled voltage rise to maximum output. To avoid damage to the load or repeated blowing of the dc fuse, provision should be made to prevent opens. For the same reason, it is necessary that make-before-break switches be used in any multiple-voltage programming arrangement, as in figure 2-3.

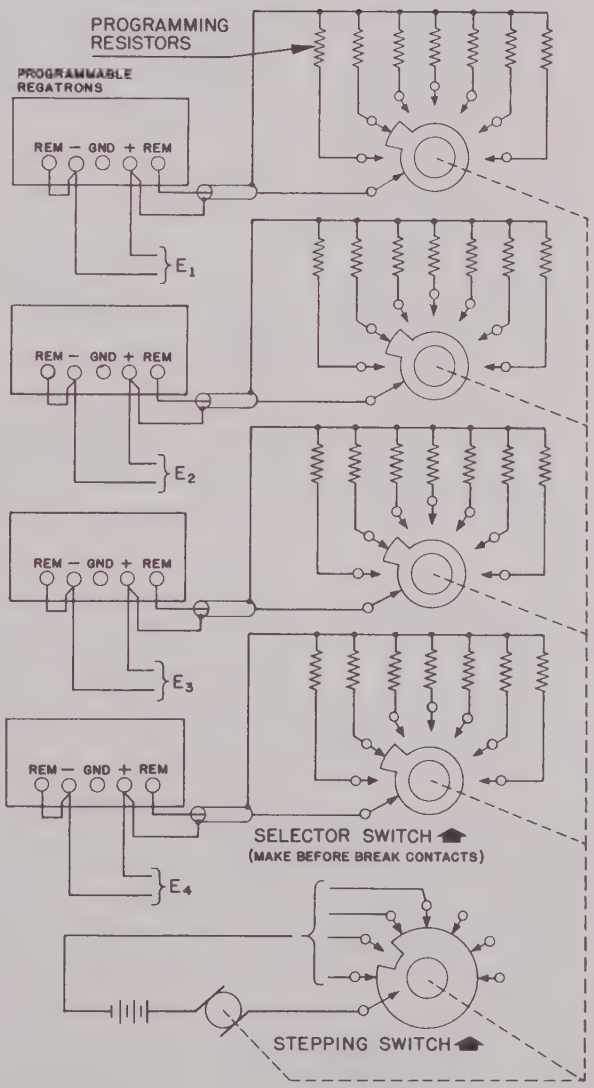


Figure 2-3. Programming with stepping switch.

b. Unless the programming resistor itself is physically shunted across the REM and + terminal posts, it is desirable to use shielded or coaxial cable, as shown in figure 2-2A, to prevent injection of ripple and noise from external sources. An insulated cable such as RG 58/U is recommended because of the fact that the coaxial sheath carries output potential.

c. For long-term or permanent programmed operation it is advisable to short out the internal controls. This will eliminate possible disturbance of programmed voltage by accidental rotation or vibration of the DC CONTROL or VERNIER.

d. Programmed operation can be combined with use of the internal controls, when convenient or necessary, merely by omitting step e. of paragraph 2-9, and adjusting controls to any desired value. In this case the value of the programming resistor will be added to the values to which the internal controls are adjusted, and the total resistance will determine output voltage.

2-12. PROGRAMMING SUGGESTIONS. Although the above programming instructions are illustrated with a single, fixed resistor as the remote control, it is evident that variable resistors, driven potentiometers, or fixed resistors wired to stepping switches can be employed to deliver voltages in a wide variety of time/amplitude patterns.

The time required for switching from one programmed voltage to another varies from the seconds range to the milliseconds range, depending upon conditions. Modifications for special switching times are available on special order from the factory.

It is also evident that programming can be manually or automatically actuated. As an example of automatic programming, figure 2-3 illustrates a four-level rotary stepper switch, each level of which controls one Regatron supply. As shown, the entire battery can be stepped through a sequence of four programmed outputs upon command.

In an extensive system, a central board may contain the switches or rheostats for the programming of several Regatron power supplies in different locations. In such a system it is practical to calibrate the control elements directly to dial markings, remembering that the accuracy of calibration depends upon the accuracy of the resistance and/or the dial markings.

2-13. OVERVOLTAGE OPERATION. This power supply is capable of voltage output higher than the specified maximum, at reduced output current. For overvoltage an external programming resistor must be employed to substitute for or add to the resistance of the DC CONTROL and VERNIER in order to extend the control resistance range and, therefore, the output range. The overvoltage capability graph indicates the output current available at voltages beyond the rated maximum of the power supply. This graph will be found at the end of this manual or can be obtained from the factory upon request.

2-14. REFERENCE AGING. The voltage reference tube employed in this power supply exhibits progressive change of voltage with aging, typically, 0.5% for 1,000 hours of use. The resulting error at the output remains at a constant percentage throughout the voltage range of the power supply, but the absolute error varies directly with the output setting. Periodic calibration by the method described in paragraph 4-4 may be performed to eliminate any error due to aging of the reference tube.

2-15. EXTERNAL REFERENCE CONNECTION. If higher accuracy is required than is provided by the internal reference, a stable external reference source of at least 85 volts can be employed. The external reference source, which should be capable of at least 1 milliampere, is connected via the rear-mounted terminal board TB1 as follows:

a. Remove the link across terminals 2 and 3 of TB1.

b. Connect the external reference across terminals 1 and 2 with the positive at terminal 1.

An external reference of between 85 and 87 volts may be directly connected as described. Above 87, each additional volt requires the insertion of 1,000 ohms of resistance between the external reference and terminal 2 on TB1 of the power supply. Thus an external reference of -150 volts requires a resistor of 63,000 ohms ±1%. The resistor should be a wirewound type using high stability alloy, since it directly affects the stability of the output voltage from the power supply.

2-16. USE AS VOLTAGE STANDARD. If a precision decade box is available for use as a remote programming control this power supply will serve as a voltage standard the accuracy of which (neglecting aging of the reference) will be slightly poorer than that of the decade box, even for a decade accuracy of 0.1%.

With the decade box connected as the remote programming resistor, output voltage will be indicated directly by the decade dials. Thus, the thousand-ohm-per-step dial indicates volts, the 10,000-per-step dial indicates tens of volts, and the 100,000-per-step dial indicates hundreds of volts.

In voltage-standard use the power supply should be calibrated as described in paragraphs 4-5 and 4-6; error due to aging of the internal reference can be

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Parts list corrections:

J3 Change Manufacturer to Eby.

R66,67 Delete (Model 228A/AK)

XV12-XV23 Delete XV23 and add XV19. Change manufacturer to Eby.

XV20,21 Change manufacturer to Eby.

XV22,23 Change manufacturer to Eby.

nullified by periodic recalibration. If an external reference is to be employed, the calibration should be performed after connection of the external source (paragraph 2-15). It is also evident that, for minimal drift, the chopper-stabilized version of this power supply should be employed.

2-17. CONVERSION TO CONSTANT-CURRENT. For conversion from constant-voltage to constant-current output, proceed as follows:

a. Select a sample resistor, R_S in Figure 2-4 below, which will carry the load current and develop a sample voltage for the control system. To determine its value, select a sample voltage. Five to 10 volts is a good range. Although the voltage may be made as high as desired it must be remembered that the sample voltage subtracts from the available output voltage. If E_S is the sample voltage and I_L is the desired load current, then $R_S = E_S/I_L$, where R_S is in ohms and I_L is in amperes. The actual wattage will be $E_S \times I_L$. The resistor used should have a somewhat higher wattage rating.

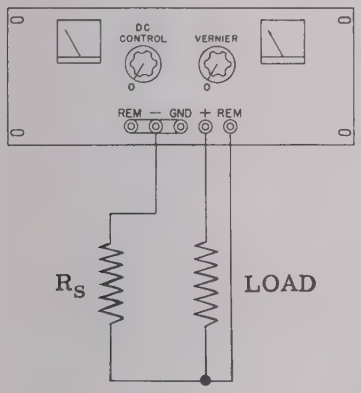


Figure 2-4.

Conversion to constant-current operation.

b. Make connections as shown in Figure 2-4 and set both panel controls to zero.

c. Throw REM-LOC switch to REM.

d. Throw the LINE switch on.

e. Bring current up to the desired value by turning the VERNIER up to the voltage selected as the sample in step a. above. In constant-current operation the VERNIER is the output control (for sample voltages up to 10 volts).

The conversion described above provides good dc regulation. The ac impedance of the power supply, however, is relatively low, and this should be noted in considering applications.

2-18. CHOPPER STABILIZED OPERATION. As stated in the specifications table, this unit achieves regulation of 0.01% or 3 mv, and stability of 0.05% + 2 mv for 8-hours when equipped with chopper stabilization. Although both ratings are conservative, note that the stability figure is specified with the unit in programmed operation, using an external resistor of high electrical and (in the case of a variable resistor) high mechanical stability. This rating can be realized only in such operation, and with the internal controls shorted out or set to zero to prevent them from contributing variations resulting from accidental rotation or vibration.

SECTION 3
CIRCUITRY

Note: Circuit references are made to the schematic diagram, except where indicated.

3-1. GENERAL. This power supply employs a full-wave rectifier, the positive output of which is applied to series amplifiers controlled by the regulator loop. The resulting regulated dc voltage constitutes the output.

3-2. CONTROL SYSTEM, LOCAL AND PROGRAMMED. Figure 3-1 illustrates the output control configuration in simplified form. If inputs G_1 and G_2 are equal (E_D=0) then:

$$\frac{E_o}{E_R} = \frac{R_1}{R_2} \text{ and } E_o = E_R \times \frac{R_1}{R_2}$$

where E_o = regulated output voltage
E_R = internal reference voltage
and R_2 is a fixed resistor.

Since E_R and R_2 are constant, $E_0 = KR_1$; or, the output voltage is dependent only upon the value of R_1 which, in local operation of the power supply, consists of the DC CONTROL and VERNIER. In programmed operation, R_1 is the remote programming

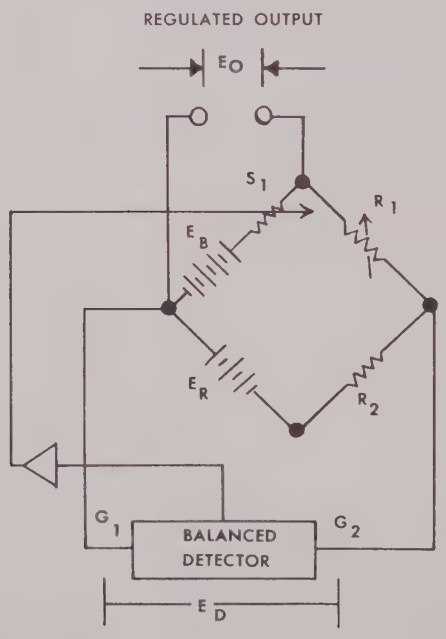


Figure 3-1. Output control configuration.

resistor in either local or programmed operation, the voltage output = $0.001R_1$, or, 1,000 ohms control resistance per volt of output.

In practice, R_2 can be adjusted with the CAL control (on the panel) for exact 1,000 ohms-per-volt programmed operation, or to calibrate output with panel dial markings.

3-3. REGULATOR SYSTEM. The regulator system employs a balanced input detector, V11, connected from the zero point of the input bleeder to the negative reference point to detect departures from balance. The amplifier error is applied to a high gain amplifier, V8, the output of which is applied to a cathode follower, V7, for sufficient current gain to drive the grids of the series amplifiers (starting with V12) in such a manner as to overcome the error. Because of the high gain of the system the error at equilibrium is very small. Reference tube V6 maintains a very stable reference potential. Gas tube V5 preregulates the potential at the cathode of V8, and gas tubes V1 through V4 maintain steady potential for the tubes of the regulator system.

3-4. UNREGULATED SUPPLY. The main dc supply employs silicon diodes in single or paralleled full-wave rectifier bridge connection, with filtering by several electrolytic capacitors starting with C1, and a 20,000 ohm bleeder resistor R1, which discharges the filters upon turn-off of the power supply. A full-wave bridge of silicon rectifiers, CR5 through CR8, comprise the screen supply for the series amplifiers, with filtering by C4. This screen supply, the negative of which is returned to the cathodes of the series amplifiers, also serves as plate supply for the cathode follower V7 and high gain amplifier V8. Rectifiers CR12, CR13, and CR14 deliver negative dc potential for the reference system, with filtering by C6. Rectifiers CR9, CR10, and CR11 deliver positive dc potential for the plate of V11 and the chopper-stabilizer amplifier, when installed.

3-5. REFERENCE. The internal reference potential for the regulator of the power supply is obtained by three stages of regulation of the potential from rectifiers CR12, CR13, and CR14. The regulated -150 volts from v/r tube V3, a type OA2, is further regulated at 108 volts by V4, a type OB2, for service at the cathodes of the balanced input detector V11. Further preregulation at -85 volts for the cathode of amplifier V8 is accomplished by an 85A2 gas-filled tube V5. The stable reference potential of -85 volts utilized at the output control configuration shown in figure 3-1 is developed by another type 85A2, tube V6. CAL control R20, in the input bridge, permits calibration of the control

system to a precise output voltage based upon the exact potential across V6, and permits periodic recalibration to eliminate error resulting from aging of V6. When an external reference is employed (see paragraph 2-15) tube V6 is disconnected from the control system by the removal of the link across terminals 2 and 3 on TB1.

A type 1N34A diode, CR15, functions as a one-way switch. CR15 disconnects V4 from the junction of R8 and R9 to permit momentary application of the high firing potential through R12. As soon as V4 has fired CR15 closes the path from the junction of R8 and R9, permitting normal flow through V4 and clamping the momentary firing potential.

Positive service potentials are regulated at 150 volts by V1 and at 108 volts by V2 for application to the plates of V11. Diode CR16 functions in the same manner for tube V2 as CR15, described above.

3-6. SERIES AMPLIFIERS. Paralleled type 6550 or KT88 beam power pentodes starting with V12 are employed as series elements, or variable conductances. Control grids are direct coupled to the output of cathode follower V7. The cathodes of the series amplifiers, from which positive, regulated output voltage is obtained, are removed from the + output terminal when DC switch S2 is thrown off.

This also shorts the + and - terminals to protect the load from surges during standby operation. Resistor R25 provides a path for the small amount of plate current which continues to flow when the series amplifiers are biased to cutoff for zero voltage output from the power supply.

3-7. BALANCED INPUT DETECTOR. A 12AX7 cathode-coupled amplifier V11 is employed as a balanced input detector, grid 2 of which is effectively at the zero point of the control bridge (positive of the reference potential) and grid 7 at the other zero point on the opposite side of the control bridge. Regulated plate supply is taken from V2 and cathodes are returned through R17 to -108 volts regulated by V4. The NULL control R18 permits setting of the balanced input detector to zero difference between grids. Capacitor C9 bypasses degenerative ac components appearing across R18.

Output from plate 6 of V11 is applied across a coupling and voltage divider network consisting of EM10 glow discharge regulator tubes V9 and V10 and resistors R15 and R16. These tubes couple plate potential to the grid of V8, maintaining a constant voltage drop which permits the grid to follow the potential at the plate of V11, thus constituting an effective dc coupling which avoids any substantial loss of gain.

Note that the chopper-stabilized version of this power supply employs a 12AY7 in place of the 12AX7 for tube V11. Standard models include a ballast regulator RT1 to maintain a stable 6.3 volts ac across the heater of V11. The ballast is not required in the chopper-stabilized version and the RT1 socket is therefore employed for the chopper-stabilizer unit with the slight wiring changes shown on the schematic diagram.

3-8. DRIVER AMPLIFIER AND CATHODE FOLLOWER. This stage employs a 6AU6 pentode, V8, in high gain, low current operation. Output is direct-coupled to the grids of cathode follower V7, which employs both sections of a dual-triode 12AX7 in parallel. Output from V7 is direct-coupled to the control grids of the series amplifiers, completing the regulator system loop.

3-9. CHOPPER-STABILIZER. On units so equipped, the chopper-stabilizer continuously corrects for zero-offset in the balanced detector, thereby eliminating output drift from this cause. Connected across the grids of the balanced input detector V11, the chopper-stabilizer continually samples the offset at grid 2, chops it, producing a square wave, amplifies, rectifies, and filters it, and applies the resulting correction signal to grid 7 to reduce the net offset to a vanishingly small value. Without the chopper-stabilizer this stage is subject to drift to the extent that output voltage may change up to .1% or 50 millivolts for 8-hours. With chopper-stabilization stability becomes 0.05% + 2 millivolts, which represents a ten-to-fifty times improvement at low voltages, where divider action by the control bridge makes zero offset-- in an unstabilized system-- the major source of drift. Because the chopper-stabilizer adds gain of approximately 1,000 to the regulator, and because it is unable to distinguish, as it were, between offset due to drift and offset to varying line or load conditions, regulation is improved to the figure shown in the Specifications Table.

3-10. OUTPUT CIRCUITRY. Electrolytic capacitor C10 is connected across the output terminals to improve transient behavior, to lower the ac output impedance of the power supply, and to adjust the characteristic of the feedback regulator loop for stable operation. Also across the output is a diode, CR17, which protects the external load by presenting a low impedance to any reverse voltage which may develop when the unit is shut off. A type NE2 neon glow lamp, DS3, serves as a clamp to protect the internal reference V6 from voltage surges when the power supply is switched from a high to a low voltage in remote control (programmed) operation. DS3 fires momentarily but is otherwise normally inoperative. It should be noted that throwing the REM-LOC switch to REM removes the positive side of the reference from the minus side of the high voltage output, and this connection is reestablished via the programming connections shown in Figure 2-2.

SECTION 4
MAINTENANCE

Attention is called to the Warranty under which this equipment is sold, to be found at the front of this manual.

4-1. PARTS REPLACEMENT. The electrical parts list and schematic diagram at the end of this book should be employed to identify all parts to be replaced. In general, replacement parts are completely defined by the values and tolerances indicated on the parts list. The following components, however, require special attention:

a. V1, V2, V3, V4, V5, and V6. Replacement of any of these tubes will affect null balance, which should therefore be readjusted as per paragraph 4-2.

b. V6. Replacement of the 85A2 will change the internal reference voltage somewhat, and necessitate recalibration as per paragraph 4-4.

c. DC CONTROL and VERNIER controls. If either of these wirewound potentiometers is defective, it is advisable to obtain an exact replacement. If none is available locally, an order should be addressed to the factory. Any temporary substitute potentiometer should provide an arc of 280° effective rotation for the panel dial markings to represent output correctly.

4-2. NULL ADJUSTMENT. The NULL control, located on the front panel, permits adjustment of the balanced input detector to null, or zero level. This adjustment, which holds over the entire operating range, is made as follows:

a. Remove the acorn nut covering the control.

b. With the DC CONTROL and VERNIER at zero, throw the LINE switch on. After a minute (from cold start) throw the DC switch on.

c. Connect a voltmeter across TP1 (J1) and TP2 (J2). Use 3 volt dc scale or lower.

d. Adjust the NULL control for zero on the meter. A very sensitive indication can be obtained by alternately connecting and disconnecting the meter lead.

4-3. NULL ADJUSTMENT FOR CHOPPER-STABILIZED UNITS. The NULL control on the chopper-stabilized version should be set to maximum resistance for optimum operation. No attempt should be made to adjust the NULL control to zero, as described above, with the chopper-stabilizer unit removed.

4-4. CALIBRATION. The CAL control, also found on the front panel, requires adjustment for any one of three reasons:

For close agreement between panel markings and output, or for exact 1,000 ohms-per-volt ratio in programmed output, or for recalibration to either of the above upon aging or replacement of V6.

This adjustment can be performed in either of two ways: with an accurate voltmeter or with an external, precise source of voltage.

4-5. If an accurate voltmeter is employed, proceed as follows, referring to figure 4-1A.

a. Remove acorn nut covering CAL control. Connect meter across + and - terminals.

b. To calibrate panel markings turn VERNIER to zero and DC CONTROL to maximum panel marking. Place unit in operation and adjust CAL control for the maximum voltage of the power supply as indicated on the external voltmeter.

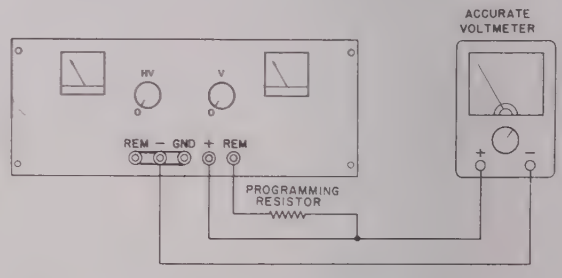


Figure 4-1A. Calibration—With Accurate Voltmeter for exact 1000 ohms-per-volt programming.

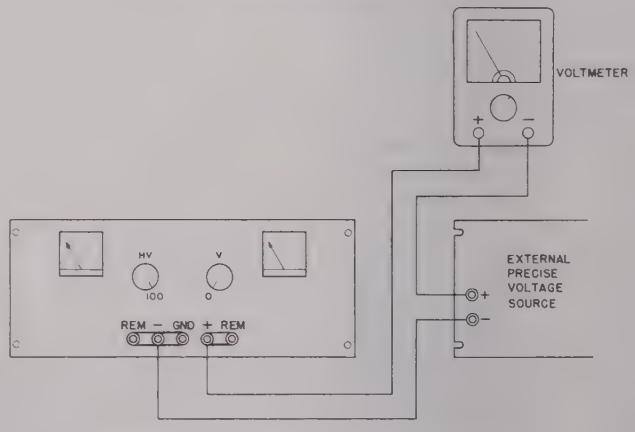


Figure 4-1B. Calibration With External, Precise Voltage Source.

c. To calibrate for exact 1,000 ohms-per-volt programming constant turn VERNIER and DC CONTROL to zero and set up the power supply for programmed operation using a programming resistor of the appropriate value to develop maximum output voltage. Place the unit in operation and adjust the CAL control for the maximum rated voltage of the power supply as indicated on the external meter.

4-6. If an external, precise source of voltage is employed, proceed as follows, referring to figure 4-1B.

a. Connect the negative outputs of the unit and the external voltage source together.

b. Connect a voltmeter between the positive terminals of the power supply and the external source.

c. Set the external source to exactly the maximum rated voltage output of the power supply.

d. To calibrate panel markings perform step c, turn VERNIER to zero and DC CONTROL to maximum panel marking. Place unit in operation and adjust CAL control for a zero reading on the external voltmeter. Use the lowest dc range available.

e. To calibrate for exact 1,000 ohms-per-volt programmed output perform step c, turn VERNIER and DC CONTROL to zero, and set up the power supply for programmed operation using a programming resistor of the appropriate value to develop maximum output voltage. Place the unit in operation and adjust CAL control for zero on the external meter.

4-7. SERIES TUBE FAULTS. In selecting replacement series tubes, or when a malfunction appears to result from a faulty series tube, the following procedure is recommended:

a. Remove all series tubes but one.

b. Turn on unit, apply 1/N of full load current at a low voltage, where N = number of series tubes.

c. Check ripple and regulation.

d. Remove this series tube, place another series tube in another socket, and repeat steps b and c. Repeat steps b and c for every other socket and tube, taking one at a time.

e. If one or more series circuits tests faulty, repeat the test in each case with a tube known to be satisfactory. If the repeated test proves favorable it may be assumed that the previous tube is defective. Otherwise the associated circuit should be checked for faults.

4-8. CLEANING AND LUBRICATION. This power supply employs forced air cooling. After extended service, therefore, considerable dust will be deposited on most surfaces within the unit. About twice a year the cover should be removed and all parts, and particularly the fan blades, should be cleansed free of dust and grime. Lubricate the fan motor once or twice a year by squeezing a few drops of light machine oil into the lubrication holes of the bearing straps.

4-9. TROUBLE SHOOTING. Referenced below are several symptoms of faults which could develop in this power supply. Opposite each symptom is the most likely cause and remedy. The table is intended as a guide to trouble shooting.

	SYMPTOM		CAUSE		REMEDY
1.	Unit is dead when LINE switch is thrown.	a.	Fuse F1 blown or defective.	a.	Replace.
2.	Fuse F1 blows repeatedly.	a.	Any rectifier CR1 through CR14 shorted.	a.	Check and replace.
3.	DC fuse F2 blows, output to zero.	a.	Short circuit load.	a.	Check load.
		b.	Overload above current rating of power supply.	b.	Check load.
		c.	Fuse F2 defective, open.	c.	Check for continuity and replace if necessary.
		d.	With load connected, DC CONTROL or VERNIER potentiometer is open.	d.	Measure resistance of potentiometers. See paragraph 4-1.
		e.	With load connected, remote control line (programming line) is open.	e.	Check remote control line for open.

		f.	Diode CR17 shorted	f. Replace.
		g.	Series amplifier tube (starting with V12) shorted with load connected.	g. Replace. See paragraphs 4-1 and 4-7.
4.	No control of output, voltmeter pins at top of scale.	a.	Series amplifier tube (starting with V12) shorted.	a. Replace. See paragraphs 4-1 and 4-7. Also check screen and cathode resistors of affected stage.
		b.	Amplifier V8 type 6AU6 defective.	b. Replace.
		c.	DC CONTROL or VERNIER open.	c. Check and replace. See paragraph 4-1.
		d.	Programming resistor or line open, in programmed operation.	d. Check programming resistor and line.
5.	No control of output, voltmeter at zero, fuse F2 not blown.	a.	Balanced input detector V11 defective.	a. Replace. See paragraph 4-1.
		b.	Ballast tube RT1 defective.	b. Replace.
		c.	Open filament on V7 or V11.	c. Replace.
6.	Voltmeter indication disagrees with control settings at full scale.	a.	Unit out of calibration.	a. Recalibrate.
7.	Output voltage lower than control setting but recalibration impossible or out of CAL range.	a.	Reference tube V6 has shifted voltage.	a. Replace. See paragraph 4-1. Also recalibrate.
8.	Output voltage lower than control setting in chopper-stabilized unit.	a.	Tube (12AX7) in chopper-stabilizer unit defective.	a. Replace.
9.	Poor line regulation.	a.	Defective V1, 2, 3, 4, 5, 6, or V11.	a. Replace. See paragraph 4-1.
		b.	Defective rectifier CR1, 2, 3, or CR4.	b. Replace.
10.	Poor load regulation.	a.	Poor load connections or high resistance in load leads.	a. Check load connections.
		b.	Series amplifier tube (starting with V12) defective.	b. Replace. See paragraphs 4-1 and 4-7.
		c.	Chopper inoperative.	c. Replace chopper.
11.	Excessive zero-offset (drift) in chopper-stabilized unit.	a.	Tube V11 defective.	a. Replace.
		b.	Chopper inoperative.	b. Replace.
12.	NULL adjustment impossible.	a.	Fuse F2 blown.	a. Replace.
		b.	Defective V1, 2, 3, 4, 5, 6, 9, 10, or V11.	b. Replace.

13. High ripple.	a.	In programmed operation, programming resistor or control line are coupling stray ac signal to power supply.	a. Shield programming resistor and/or control line.
	b.	Defective V3, 4, 5, 6, 7, 8, or V11.	b. Replace.
	c.	Defective C1, 2, 3, 4, 5, 10, or C11.	c. Replace.
14. DC output changes abruptly at periodic rate.	a.	Defective V1, 2, 3, 4, 5, 6, 9, or V10.	a. Replace. Recalibrate if V6 is replaced.

4-10. VOLTAGE AND RESISTANCE TABLES. Voltage and resistance values in the table supplied with this manual are nominal and may vary as much as 20% among production units without causing difficulties. The conditions of measurement are as follows:

For resistance measurements:

a. AC line cord not connected to power.

b. No load connected.

c. LINE and DC switches off. Floating output (swinging link disconnected from + or - post). REM-LOC switch at LOC.

d. DC CONTROL and VERNIER at zero.

e. Readings from indicated tube pins to - (minus) output post.

For voltage measurements, using a 20,000 ohms-per-volt meter:

a. Line input 115 volts ac. LINE and DC switches on.

b. VERNIER at maximum and DC CONTROL at correct additive setting for maximum rated voltage output.

c. No load connected.

d. Floating output (swinging link disconnected from + or - output post). REM-LOC switch at LOC.

e. Readings from indicated tube pins to - (minus) output post.

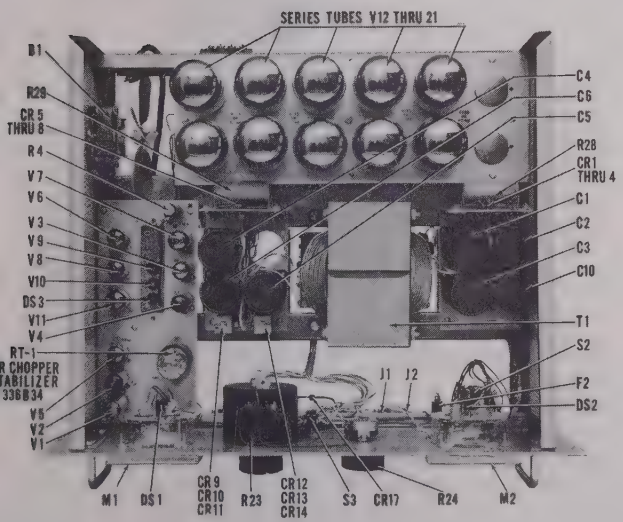


Figure 4-2. Parts Locations.

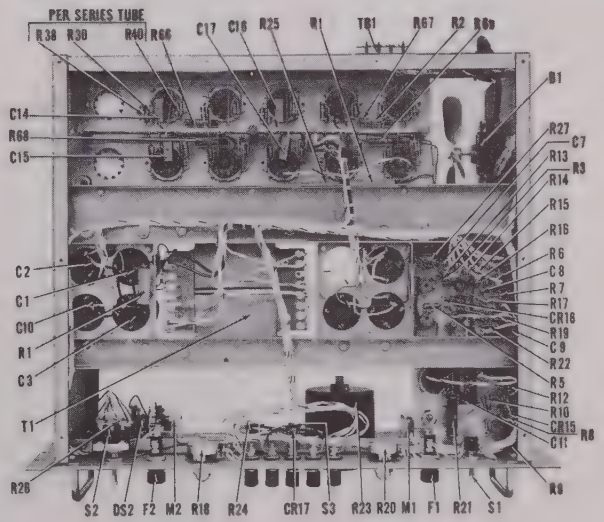


Figure 4-3. Parts Locations.

MODEL 225A

TUBE	RESISTANCES PIN 1	2	3	4	5	6	7	8	9	VOLTAGES PIN 1	2	3	4	5	6	7	8	9	TUBE
V1	.7 meg	0	∞	0	.7 meg	∞	0			150	-	-	-	150	-	-			V1
V2	5 meg	0	∞	0	5 meg	∞	0			108	-	-	-	108	-	-			V2
V3	0	20K	∞	20K	0	∞	20K			-	-150	-	-150	-	-	-150			V3
V4	0	20K	∞	20K	0	∞	20K			-	-108	-	-108	-	-	-108			V4
V5	0	20K	0	20K	0	∞	20K			-	-85	-	-85	-	-	-85			V5
V6	0	40K	0	40K	0	∞	40K			-	-85	-	-85	-	-	-85			V6
V7	∞	∞	200K	0	0	∞	∞	200K	0	350	40	42	6.3ac	6.3ac	350	40	42	0	V7
V8	160K	40K	0	0	∞	160K	40K			-95	-90	6.3ac	-	40	-43	-90			V8
V9	400K at junction R19 & V11 pin 6									-85 at junction R19 & V11 pin 6									V9
V10	400K at junction R15 & V9									33 at junction R15 & V9									V10
V11	∞	5	200K	0	0	1 meg	0	150K	0	115	-	1.04	-	-	32	-	1.3	6.3ac	V11
V12 thru V23	∞	0	10K	∞	200K	20K	0	1 meg		-	6.3ac	180	360	42	-155*		80		V12 thru V23

MODEL 226A

TUBE	RESISTANCES PIN 1	2	3	4	5	6	7	8	9	VOLTAGES PIN 1	2	3	4	5	6	7	8	9	TUBE
V1	1.5 meg	0	∞	0	1.5 meg	∞	0			150	-	-	-	150	-	-			V1
V2	5 meg	0	∞	0	1.5 meg	∞	0			108	-	-	-	108	-	-			V2
V3	0	20K	∞	20K	0	∞	20K			-	-150	-	-150	-	-	-150			V3
V4	0	20K	∞	20K	0	∞	20K			-	-108	-	-108	-	-	-108			V4
V5	0	120K	0	20K	0	∞	20K			-	-85	-	-85	-	-	-85			V5
V6	0	210K	0	40K	0	∞	40K			-	-85	-	-85	-	-	-85			V6
V7	∞	∞	200K	0	0	∞	∞	200K	0	400	70	70	6.3ac	6.3ac	400	70	70	0	V7
V8	400K	40K	0	0	∞	160K	40K			-95	-90	6.3ac	-	70	-55	-90			V8
V9	400K at junction R19 & V11 pin 6									-85 at junction R19 & V11 pin 6									V9
V10	500K at junction R15 & V9									36 at junction R15 & V9									V10
V11	∞	5	200K	0	0	5 meg	0	150K	0	115	-	1.05	-	-	36	-	1.3	6.3ac	V11
V12 thru V23	∞	0	20K	∞	200K	20K	0	1 meg		-	6.3ac	220	400	75	-155*	-	105		V12 thru V23

MODEL 228

TUBE	RESISTANCES PIN 1	2	3	4	5	6	7	8	9	VOLTAGES PIN 1	2	3	4	5	6	7	8	9	TUBE
V1	.3 meg	0	∞	0	.3 meg	∞	0			150	-	-	-	150	-	-			V1
V2	.3 meg	0	∞	0	.3 meg	∞	0			108	-	-	-	108	-	-			V2
V3	0	20K	∞	20K	0	∞	20K			-	-150	-	-150	-	-	-150			V3
V4	0	20K	∞	20K	0	∞	20K			-	-108	-	-108	-	-	-108			V4
V5	0	20K	0	20K	0	∞	20K			-	-85	-	-85	-	-	-85			V5
V6	0	40K	0	40K	0	∞	40K			-	-85	-	-85	-	-	-85			V6
V7	70	∞	250K	0	0	70	∞	250K	0	420	120	125	6.3ac	6.3ac	420	120	125	0	V7
V8	400K	40K	0	0	∞	160K	40K			-95	-90	6.3ac	-	120	-44	-90			V8
V9	400K at junction R19 & V11 pin 6									-85 at junction R19 & V11 pin 6									V9
V10	500K at junction R15 & V9									43 at junction R15 & V9									V10
V11	∞	5	200K	0	0	.5 meg	0	150K	0	115	-	.9	-	-	43	-	1.02	6.3ac	V11
V12 thru V19	∞	0	20K	20K	200K	20K	0	1 meg		-	6.3ac	260	420	125	-155*	-	155		V12 thru V19

MODEL 230

TUBE	RESISTANCES PIN 1	2	3	4	5	6	7	8	9	VOLTAGES PIN 1	2	3	4	5	6	7	8	9	TUBE
V1	.8 meg	0	∞	0	.8 meg	∞	0			150	-	-	-	150	-	-			V1
V2	.8 meg	0	∞	0	.8 meg	∞	0			108	-	-	-	108	-	-			V2
V3	0	20K	∞	20K	0	∞	20K			-	-150	-	-150	-	-	-150			V3
V4	0	20K	∞	20K	0	∞	20K			-	-108	-	-108	-	-	-108			V4
V5	0	20K	0	20K	0	∞	20K			-	-85	-	-85	-	-	-85			V5
V6	0	40K	0	40K	0	∞	40K			-	-85	-	-85	-	-	-85			V6
V7	∞	∞	220K	0	0	∞	∞	220K	0	480	165	170	6.3ac	6.3ac	480	165	170	0	V7
V8	400K	40K	0	0	∞	160K	40K			-95	-90	6.3ac	-	165	-43	-90			V8
V9	400K at junction R19 & V11 pin 6									-85 at junction R19 & V11 pin 6									V9
V10	500K at junction R15 & V9									33 at junction R15 & V9									V10
V11	∞	5	200K	0	0	∞	0	200K	0	115	-	1	-	-	33	-	1.2	6.3ac	V11
V12 thru V21	∞	0	20K	300K	220K	20K	0	1 meg		-	6.3ac	320	470	170	-155*	-	205		V12 thru V21

* Tie point only

357-D-1-(B)
357-D-2-(A)
357-D-3-(B)
357-D-4-(B)

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
B1	Motor, shaded pole, 115V, 50-60 CPS, 4 in. fan blade	DYAB-570-3	Barber-Colman
C1,2,4,10	Capacitor, electrolytic, 320 UF, 300 VDC, insl. sleeve (Models 225,226A/AK)	D31962	Sprague
C1,2,3,10	Capacitor, electrolytic, 120 UF, 450 VDC, insl. sleeve (Models 228,230A/AK)	D32346	Sprague
C4	Capacitor, electrolytic, 320 UF, 300 VDC, insl. sleeve (Models 228,230A/AK)	D31962	Sprague
C5,6	Capacitor, electrolytic, 80 UF, 450 VDC, insl. sleeve	D15911	Sprague
C7	Capacitor, mica, 100 UUF ±5%, 500 VDC	CM20B101-J	Micamold
C8	Capacitor, mica, 220 UUF ±5%, 500 VDC	CM20B221-J	Micamold
C9	Capacitor, electrolytic, 25 UF, 25 VDC	KE-25/25	Frako
C11	Capacitor, mylar, 0.5 UF ±20%, 400 VDC	Type 2110BM	Chicago Cond.
C12	Capacitor, mica, 15 UUF ±5%, 500 VDC	CM20B150-J	Micamold
C14,15	Capacitor, mica, 2200 UUF ±5%, 500 VDC (228A/AK)	CM30B222-J	Micamold
C16,17	Same as C14,15 (Models 225,226,230A/AK)		
CR1-CR4	Rectifier, silicon	CER71	Solitron
CR1A-CR4A	Same as CR1-CR4 (Models 225,226A/AK)		
CR5-8,CR17	Same as CR1-CR4		
CR9-CR14	Rectifier, selenium	8J1	Radio Receptor
CR15,16	Diode, germanium	1N34A	Sylvania
CORD	Cord set, 7' lg. #18 gauge, 3 cond., 3 prong plug	346-B-52	EMC
DS1,2	Bulb, 6.3V, 0.25A	44	G.E.
DS3	Bulb, neon	NE-2	EMC
E1,2	Post, binding, red	29-3R	Grayhill
E3,4,5	Post, binding, black	29-3B	Grayhill
E6	Shorting link	938-L	General Radio
E7	Shorting link	141-J	Cinch Jones
F1	Fuse, cartridge, 6A (Models 228,230A/AK)	3AG6	Sightmaster
F1	Fuse, cartridge, 8A (Models 225,226A/AK)	3AG8	Sightmaster
F2	Fuse, cartridge, 1A (Models 228,230A/AK)	3AG1	Sightmaster
F2	Fuse, cartridge, 2A (Models 225,226A/AK)	3AG2	Sightmaster
J1,2	Tip jack, nylon	105-603	E.F. Johnson
J3	Socket, 8 pin, octal (stabilizer unit or Ballast tube)	9751-9	Cinch Jones
M1	Ammeter, 0-2 ADC ±2% accuracy full scale (Models 225,226 AM/AMK)	Model 653/A2	EMC
M1	Ammeter, 0-1 ADC ±2% accuracy full scale (Models 228,230 AM/AMK)	Model 653/A1	EMC
M2	Voltmeter, 0-75 VDC ±2% accuracy full scale (Model 225AM/AMK)	Model 653/V75	EMC
M2	Voltmeter, 0-100 VDC ±2% accuracy full scale (Model 226AM/AMK)	Model 653/V100	EMC
M2	Voltmeter, 0-150 VDC ±2% accuracy full scale(Model 228AM/AMK)	Model 653/V150	EMC
M2	Voltmeter, 0-200 VDC ±2% accuracy full scale(Model 230AM/AMK)	Model 653/V200	EMC
R1	Resistor, fixed, WW, ceramic, 20Kn ±5%, 5W	Koolohm 5KT20K	Sprague
R2,3,12	Resistor, fixed, comp, 1 megn ±10%, ½W	EB-1051	Allen-Bradley
R4	Resistor, fixed, WW, vitreous enamel, 10Kn ±5%, 20W	Type Brown Devil	Ohmite
R5	Resistor, fixed, comp, 5.1Kn ±5%, 1W	GB-5125	Allen-Bradley
R6	Resistor, fixed, comp, 390Kn ±10%, ½W	EB-3941	Allen-Bradley
R7	Resistor, fixed, comp, 330Kn ±10%, ½W	EB-3341	Allen-Bradley
R8	Resistor, fixed, comp, 5.6Kn ±5%, 1W	GB-5625	Allen-Bradley
R9	Resistor, fixed, comp, 3.6Kn ±5%, 1W	GB-3625	Allen-Bradley
R10	Resistor, fixed, comp, 22Kn ±10%, 1W	GB-2231	Allen-Bradley
R11	Resistor, fixed, WW, ceramic, 4Kn ±5%, 10W	Koolohm 10KT4K	Sprague
R13,19	Resistor, fixed, comp, 220Kn ±10%, 1W	GB-2241	Allen-Bradley
R14,15	Resistor, fixed, comp, 100Kn ±10%, ½W	EB-1041	Allen-Bradley
R16	Resistor, fixed, comp, 330Kn ±10%, ½W	EB-3341	Allen-Bradley
R17	Resistor, fixed, comp, 150Kn ±10%, 1W	GB-1541	Allen-Bradley
R18	Resistor, variable, WW, 3Kn ±5%, 2W, linear taper, ¼ in. dia., 1/8 in. lg. slotted shaft, series 43	CM18923	Clarostat
R20	Resistor, variable, WW, 10Kn ±5%, 2W, linear taper, ¼ in. dia., 1/8 in. lg. slotted shaft, series 43	CM18924	Clarostat
R21	Resistor, fixed, WW, 76Kn ±1%, 3W	Type P3W	Precision Resistor
R22	Resistor, fixed, WW, 3Kn ±1%, ½W	Type TX-178	Precision Resistor
R23	Resistor, variable, WW, 75Kn ±5%, 3W, linear taper, ¼ in. dia., ½ in. lg. shaft, series 58 (Model 225A/AK)	CM26323	Clarostat
R23	Resistor, variable, WW, 100Kn ±5%, 4W, linear taper, ¼ in. dia., ½ in. lg. shaft, series 10, (Model 226A/AK)	CM18927	Clarostat
R23	Resistor, variable, WW, 150Kn ±2%, 8W, linear taper, 3/8 in. dia., insl. shaft (Model 228A/AK)	976-S1	General Radio
R23	Resistor, variable, WW, 200Kn ±2%, 8W, linear taper, 3/8 in. dia., insl. shaft (Model 230A/AK)	976-T	General Radio
R24	Resistor, variable, WW, 10Kn ±5%, 2W, linear taper, ¼ in. dia., ½ in. lg. shaft, series 43	CM21189	Clarostat
R25	Resistor, fixed, WW, ceramic, 25Kn ±5%, 10W	Koolohm 10KT25K	Sprague
R26	Resistor, fixed, comp, 4.7n ±5%, 1W	GB-4705	Allen-Bradley
R27	Resistor, fixed, comp, 4.7 megn ±10%, ½W	EB-4751	Allen-Bradley
R28,29	Resistor, fixed, WW, vitreous enamel, 3n ±5%, 25W	25F3	Ward Leonard
R28A	Same as R28,29 (Models 225,226A/AK)		
R30-R37	Resistor, fixed, comp, 82n ±10%, 1W (Models 225,226,228, 230A/AK)	GB-8201	Allen-Bradley
R38,39,42,43, 46,47,50,51	Resistor, fixed, comp, 470n ±10%, 1W (Models 225,226,228, 230A/AK)	GB-4711	Allen-Bradley

PARTS LISTS

R40,41,44,45, 48,49,52,53	Resistor, fixed, comp, 10Ω ±10%, 1W (Models 225,226,228, 230A/AK)	GB-1001	Allen-Bradley
R54,55	Same as R38, etc. (Models 225,226,230A/AK)		
R56,57	Same as R40, etc. (Models 225,226,230A/AK)		
R58,59	Same as R30, etc. (Models 225,226,230A/AK)		
R60,61	Same as R30, etc. (Models 225,226A/AK)		
R62,63	Same as R38, etc. (Models 225,226A/AK)		
R64,65	Same as R40, etc. (Models 225,226A/AK)		
R66,67	Resistor, fixed, WW, 1Ω ±5%, 1W (Model 228A/AK)	BW-1	Int'l. Resistance
R68,69	Same as R66,67 (Models 225,226,230A/AK)		
RT1	Ballast tube	AMP 3-4	Amperite
S1	Switch, toggle, SPST	160-73	Carling Electric
S2	Switch, toggle, TPDT	HL233-73	Carling Electric
S3	Switch, toggle, DPST	2BK-62-73	Carling Electric
T1	Transformer, power (Models 225,226A/AK)	5066	EMC
T1	Transformer, power (Models 228,230A/AK)	5076	EMC
TB1	Barrier strip, 3 terminal	3-141-Y	Cinch Jones
TB2	Barrier strip, 5 terminal (rear termination only)	5-141-Y	Cinch Jones
V1,3	Electron tube	0A2	RCA
V2,4	Electron tube	0B2	RCA
V5,6	Electron tube	85A2/0G3	Amperex
V7	Electron tube	12AX7	RCA
V8	Electron tube	6AU6	RCA
V9,10	Electron tube	EM10	EMC
V11	Electron tube (Models 225,226,228,230A)	12AX7	RCA
V11	Electron tube (Models 225,226,228,230AK)	12AY7	G.E.
V12-19	Electron tube (Models 225,226,228,230A/AK)	6550 or KT88	Tung- Sol British Ind.
V20,21	Same as V12, etc. (Models 225,226,230A/AK)		
V22,23	Same as V12, etc. (Models 225,226A/AK)		
XDS1	Holder assembly, pilot bulb, green faceted lens	100	Drake Mfg.
XDS2	Holder assembly, pilot bulb, red faceted lens	100	Drake Mfg.
XF1,2	Extractor post, fuse, miniature	342003	Littelfuse
XV1-6,8	Socket, 7 pin, miniature	53P24022	Cinch Jones
XV7,11	Socket, 9 pin, noval	14502	Cinch Jones
XV12-XV23	Socket, 8 pin, octal (Models 225,226,228,230A/AK)	9751-9	Cinch Jones
XV20,21	Socket, 8 pin, octal (Models 225,226,230A/AK)	9751-9	Cinch Jones
XV22,23	Socket, 8 pin, octal (Models 225,226A/AK)	9751-9	Cinch Jones

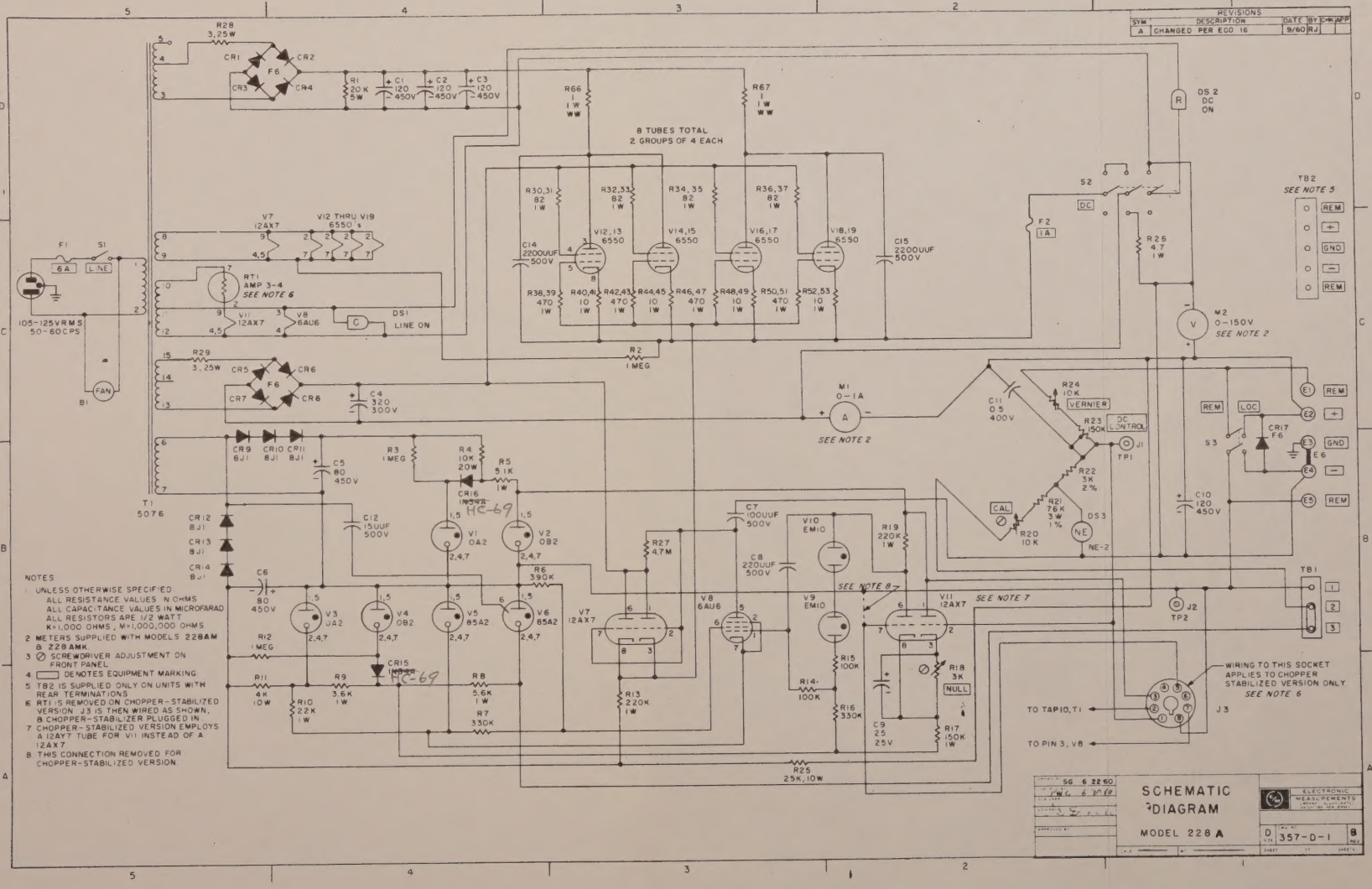
ELECTRICAL PARTS LIST 5/61

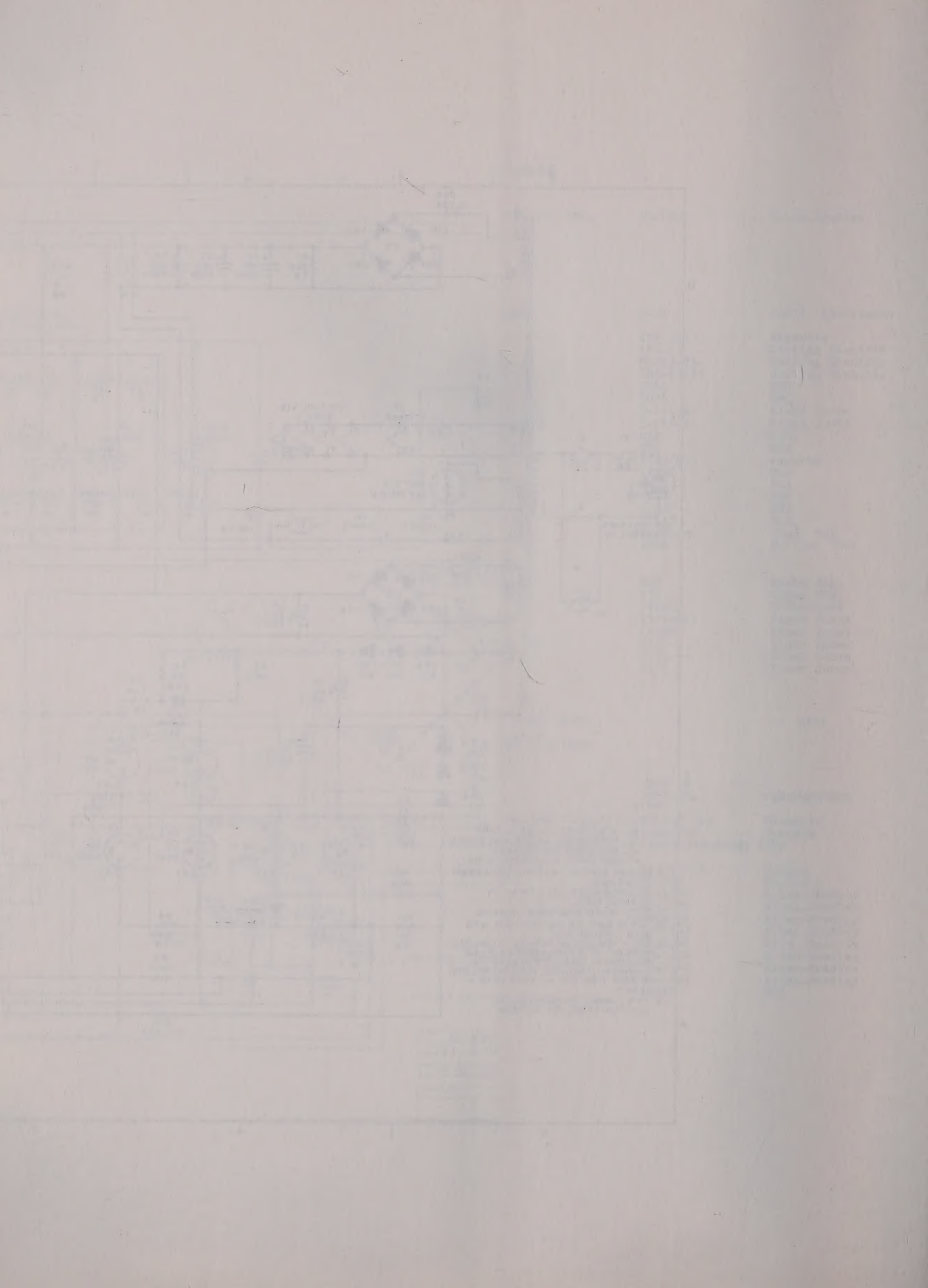
CHOPPER STABILIZER UNIT

336B34

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
C1	Capacitor, mica, 27 UUF ±5%, 500 VDC	CM19B270-J	Micamold
C2,3,4	Capacitor, mylar, 0.022 UF ±10%, 200 VDC	Type 107	Pyramid
C5	Capacitor, electrolytic, non-polarized, tantalum, 20 UF, 25 VDC	TAE20-25SDLK-NP	*IEI
K1	Chopper, SPDT, 6.3V, 60 CPS	Model 175	Airpax
P	Plug, octal, 8 pin	86-CP8	Amphenol
R1	Resistor, fixed, comp, 120KΩ ±10%, ½W	EB-1241	Allen-Bradley
R2	Resistor, fixed, comp, 33KΩ ±10%, ½W	EB-3331	Allen-Bradley
R3,6	Resistor, fixed, comp, 4.7 megΩ ±10%, ½W	EB-4751	Allen-Bradley
R4	Resistor, fixed, comp, 100KΩ ±10%, ½W	EB-1041	Allen-Bradley
R5,7	Resistor, fixed, comp, 680KΩ ±10%, ½W	EB-6841	Allen-Bradley
R8	Resistor, fixed, comp, 56KΩ ±10%, ½W	EB-5631	Allen-Bradley
R9	Resistor, fixed, comp, 270KΩ ±10%, ½W	EB-2741	Allen-Bradley
R10	Resistor, fixed, comp, 1 megΩ ±10%, ½W	EB-1051	Allen-Bradley
V1	Electron tube	12AX7	RCA

* International Electronic Industries, Inc.


REVISIONS
SYM DESCRIPTION DATE BY CHK APP
A CHANGED PER ECO 16 9/60 RJ
8 TUBES TOTAL
2 GROUPS OF 4 EACH
105-125 VRMS 50-60 CPS
NOTES
1 UNLESS OTHERWISE SPECIFIED
ALL RESISTANCE VALUES IN OHMS
ALL CAPACITANCE VALUES IN MICROFARAD
ALL RESISTORS ARE 1/2 WATT
K=1,000 OHMS, M=1,000,000 OHMS
2 METERS SUPPLIED WITH MODELS 228AM & 228AMK.
3 ⊘ SCREWDRIVER ADJUSTMENT ON FRONT PANEL.
4 ▭ DENOTES EQUIPMENT MARKING.
5 TB2 IS SUPPLIED ONLY ON UNITS WITH REAR TERMINATIONS.
6 RT1 IS REMOVED ON CHOPPER-STABILIZED VERSION. J3 IS THEN WIRED AS SHOWN. 8 CHOPPER-STABILIZER PLUGGED IN.
7 CHOPPER-STABILIZED VERSION EMPLOYS A 12AY7 TUBE FOR V11 INSTEAD OF A 12AX7.
8 THIS CONNECTION REMOVED FOR CHOPPER-STABILIZED VERSION.
SEE NOTE 2
SEE NOTE 6
SEE NOTE 7
SEE NOTE 8
WIRING TO THIS SOCKET APPLIES TO CHOPPER STABILIZED VERSION ONLY
TO TAP 10, T1
TO PIN 3, V8
SCHEMATIC DIAGRAM
MODEL 228A
ELECTRONIC MEASUREMENTS
D 357-D-1
8



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